Bulletin of the Museum of Comparative Zoology

AT HARVARD COLLEGE

Vol. 123, No. 9

THE SPITSBERGEN ARCTOCERATIDS

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WITH NINE PLATES

PRINTED FOR THE MUSEUM

CAMBRIDGE, MASS., U.S.A.

March, 1961

No. 9 — *The Spitsbergen Arctoceratids*

By Bernhard Kummel

The most characteristic ammonoids of the Lower Triassic deposits of Spitsbergen are species of the genus *Arctoceras*. Lindström (1865), Oberg (1877), and Mojsisovics (1886) together have described 7 species (under the genus *Ceratites*) that have been assigned to *Arctoceras* since Hyatt (1900, p. 559) established the genus designating *Ceratites polaris* as the type. The species of *Arctoceras* from Spitsbergen are as follows:

A. blomstrandi (Lindström)
A. simplex (Mojsisovics)
A. polare (Mojsisovics)
A. whitei (Mojsisovics)
A. öbergi (Mojsisovics)
A. lindströmi (Mojsisovics)
A. costatus (Oberg)

The specimens upon which these species were based came from the *Posidonomya* beds at Isfjord-Kolonie, Spitsbergen. Spath (1921, 1934) had opportunity to study additional large collections from the same horizon at a number of different localities and accepted all of the species previously described even though he clearly recognized the presence of numerous transitions between all of the species. Frebold (1930) likewise studied specimens of this genus from Spitsbergen and accepted all of the species then known.

Between the time of the original description of these species by Lindström, Öberg, and Mojsisovics and the later studies by Frebold and Spath, there was published a most interesting commentary on the Spitsbergen arctoceratids by Wepfer (1912, p. 7, footnote) which reads as follows: "E. v. Mojsisovics hat in den 'arktischen Triasfaunen' 32 Ceratiten aus den Poisdonienschichten von Spitzbergen beschrieben unter den teilweise neuen Namen *simplex*, *Whitei*, *Blomstrandi* (Lindström), *polaris*, *costatus*, *Oebergi*, *Lindströmi*, die allesamt zu einem und demselben Typhus gehören, nämlich zu der 'Untergruppe des *Cer. polaris*.' In der Tat stehen sie sich alle sehr nahe und die Unterscheidung in sieben getrennte Spezies beruht auf recht subtilen Unterschieden. Immerhin könnte man sie gelten lassen, wenn man annehmen dürfte, dass diese 32 Stücke die Vollständigkeit der in den Posidonienschichten vorkommenden Fauna darstellen würden. Das wird aber kaum jemand behaupten wollen, wenn er in Betracht zieht, dass auf der Spitzbergener Exkursion des internationalen Geologenkongresses (an der ich teilgenommen habe) jeder Teilnehmer Dutzende von gut erhaltenen Ceratiten aus den betreffenden Schichten sammeln konnte. Ich habe z. B. über 30 Stück gesammelt; schon diese 30 nach Mojsisovics' Arbeit bestimmen zu wollen, stösst auf die grössten Schwierigkeiten, denn so und so viele Exemplare stehen in der und jener Beziehung zwischen zwei 'Spezies' and füllen somit eine (bisher künstliche) Lücke teilweise aus. — Als unbefangener Beobachter kann man nur feststellen, dass diese Ceratiten samt und sonders zu einem Typhus gehören, zu dem des *Ceratites polaris* E. v. Mojs. oder — wenn man der Priortät den Vorrang vor gänzlich unzulänglichen Figuren geben will — dem des *Cer. Bloemstrandi* Lindstr. Es ist stets tief zu bedauern, wenn eine Fauna beschrieben wird, solange ungenügende Aufsammlungen gemacht worden sind; hätte man damit nicht warfen können, bis von der notorisch an guten Fossilien reichen Fundstelle vollständigere Aufsammlungen vorlagen, besonders wo es sich um ein Land handelt, dessen Erreichung durchaus keine grossen Schwierigkeiten bietet? Wenn gewissermassen ein Gutachten von dem Kenner der alpinen Trias eingefordert wurde, so ist dies ganz in Ordnung; aber weswegen musste gleich alles unter neuen Speziesnamen festgelegt werden? So schmiedet sich die Paläontologie ihre eigenen Ketten."

The author has had the opportunity of examining most of the primary types of each of these species of *Arctoceras* plus a number of additional specimens. The conclusion of this study is that the *Posidonomya* beds of Spitsbergen contain only one species of *Arctoceras,* namely *A. blomstrandi* (Lindström). All the remaining species are either immature forms or morphological variants of a variable species group. In addition, it is concluded that the *Arctoceras* fauna of Spitsbergen is more likely mid-Scythian in age (Owenitan division of Spath) than late Scythian (Columbitan or Prohungaritan of Spath) as believed by most previous authors.

SYSTEMATIC PALEONTOLOGY

Arctoceras blomstrandi (Lindström)

Plate 1, figs. 1-4; Plate 2, figs. 1, 2; Plate 3, figs. 1-5; Plate 4, figs. 1-4; Plate 5, figs. 1-10; Plate 6, figs.1-4 ;Plate 7, fig. 1.

Ceratites ? blomstrandi Lindström, 1865, Kongl. Sv. Vet. Akad. Handl., vol. 6, no. 6, p. 4, pl. 1, fig. 3.

Ceratites blomstrandi, Öberg, 1877, Kongl. Sv. Vet. Akad. Handl., vol. 14, no. 14, p. 11, pl. 3, figs. 1-4; Wepfer, 1912, Palaeontographica, vol. 59, p. 7.

Ceratites costatus Öberg, 1877, Kongl. Sv. Vet. Akad. Handl., vol. 14, no. 14, pp. 13-14, pl. 4, fig. 3, *non* 4; Mojsisovics, 1886, Mém. Acad. Imp. Sci. Nat. St. Petersb., ser. 7, vol. 33, no. 6, pp. 36-37, pl. 7, fig. 3; Frech, 1905, Lethaea geognostica, vol. 1, Asiatische Trias, pl. 29, fig. 9; Wepfer, 1912, Palaeontographica, vol. 59, p. 7.

Dinarites öbergi Mojsisovics, 1882, Abh. geol. Reichsanst. Wien, vol. 10, p. 12 (for *Ceratites blomstrandi* in Öberg, 1877, pl. 3, fig. 1).

Ceratites öbergi Mojsisovics, 1886, Mém. Acad. Imp. Sci. Nat. St. Petersb., vol. 33, no. 6, pp. 33-34, pl. 7, figs. 5-6; pl. 8, figs. 1, 3; Frech, 1905, Lethaea geognostica, vol. 1, Asiatische Trias, pl. 29, fig. 7; Wepfer, 1912, Palaeontographica, vol. 59, p. 7.

Ceratites lindströmi Mojsisovics, 1886, Mém. Acad. Imp. Sci. Nat. St. Petersb., vol. 33, no. 6, p. 35, pl. 8, fig. 2; Wepfer, 1912, Palaeontographica, vol. 59, p. 7.

Ceratites simplex Mojsisovics, 1886, Mém. Acad. Imp. Sci. Nat. St. Petersb., vol. 33, no. 6, pp. 30-31, pl. 6, figs. 2-4; Wepfer, 1912, Palaeontographica, vol. 59, p. 7.

Ceratites polaris Mojsisovics, 1886, Mém. Acad. Imp. Sci. Nat. St. Petersb., vol. 33, no. 6, pp. 31-32, pl. 7, figs. 1-2; Frech, 1905. Lethaea geognostica, Bd. 1, Asiatische Trias, pl. 29, fig. 8; Wepfer, 1912, Palaeontographica, vol. 59, p. 7.

Ceratites ind. Mojsisovics, 1886, Mém. Acad. Imp. Sci. Nat. St. Petersb., vol. 33, no. 6, p. 32, pl. 6, fig. 7.

Ceratites nov. f. indet., Mojsisovics, 1886, Mém. Acad. Imp. Sci. Nat. St. Petersb., vol. 33, no. 6, p. 37, pl. 7, fig. 4; Öberg, 1877, Kongl. Sv. Vet. Akad. Handl., vol. 14, no. 14, p. 14, pl. 4, fig. 1c (only).

Ceratites whitei Mojsisovics, 1886, Mém. Acad. Imp. Sci. Nat. St. Petersb., vol. 33, no. 6, pp. 32-33, pl. 6, figs. 5-6; Wepfer, 1912, Palaeontographica, vol. 59, p. 7.

Arctoceras blomstrandi, Diener, 1915, Fossilium Catalogus, Part 8, p. 52; Spath, 1921, Geol. Mag., vol. 68, p. 299; Frebold, 1930, Skr. Svalb. og Ishavet, No. 28, pp. 19-20; Spath, 1934, British Museum Catalogue Fossil Cephalopoda, Part 4, pp. 259-260.

Arctoceras costatus, Diener, 1915, Fossilium Catalogus, Part 8, p. 52; Spath, 1921, Geol. Mag., vol. 68, p. 299; Spath, 1934, British Museum. Catalogue Fossil Cephalopoda, Part 4, pp. 262-263.

Arctoceras öbergi, Diener, 1915, Fossilium Catalogus, Part 8, p. 52; Spath, 1921, Geol. Mag., vol. 68; p. 299; Frebold, 1930, Skr. Svalb. og Ishavet, No. 28, p. 19; Spath, 1934, British Museum Catalogue Fossil Cephalopoda, Part 4, pp. 261-262.

Arctoceras lindströmi, Diener, 1915, Fossilium Catalogus, Part 8, p. 52; Spath, 1921, Geol. Mag., vol. 68, p. 299, 302; Spath, 1934, British Museum Catalogue Fossil Cephalopoda, Part 4, pp. 263-264, fig. 88c.

Arctoceras simplex, Diener, 1915, Fossilium Catalogus, Part 8, p. 52; Spath, 1921, Geol. Mag., vol. 68, p. 299; Spath, 1934, British Museum Catalogue Fossil Cephalopoda, Part 4, p. 259.

Arctoceras polare, Diener, 1915, Fossilium Catalogus, Part 8, p. 52; Spath, 1921, Geol. Mag., vol. 68, p. 299; Spath, 1934, British Museum Catalogue Fossil Cephalopoda, Part 4, pp. 257-259, fig. 88a-b.

Arctoceras sp. ind. Mojsisovics. Diener, 1915, Fossilium Catalogus. Part 8, p. 53.

Arctoceras whitei, Diener, 1915, Fossilium Catalogus, Part 8, p. 53; Spath, 1921, Geol. Mag., vol. 68, p. 297; Frebold, 1930, Skr. Svalb. og Ishavet, No. 28, pp. 18-19, pl. 5, figs. 1-3; Spath, 1934, British Museum Catalogue Fossil Cephalopoda, Part 4, pp. 260-261, fig. 89.

The illustrations of the primary types of the various species of *Arctoceras* described by Lindström, Oberg, and Mojsisovics are for the most part highly idealized drawings. These illustrations plus the accompanying descriptions (mostly brief diagnoses) by these authors are all that most students of Triassic ammonites have had available to appraise the Spitsbergen fauna. Because the original illustrations are so misleading, each of the primary types is illustrated here by unretouched photographs. In addition each of these specimens is described in terms of its preservation etc., before the group as a whole is discussed.

Ceratites blomstrandi Lindström (1865, p. 4, pl. 1, fig. 3; Mojsisovics, 1886, pp. 29-30, pl. 6, fig. 8; Pl. 1, figs. 1-2 of this report).

A poorly preserved specimen of 74.0 mm. in diameter consisting of the phragmocone and slightly less than half a whorl of body chamber. Only one side of the specimen is preserved, showing some sutures and areas where the shell is preserved. The opposite side of the conch preserves only the phragmocone to a diameter of approximately 49.0 mm. and this portion is preserved in a coarse crystalline calcite which obliterates all details. The adoral quarter whorl of the phragmocone and all of the body chamber on this side of the conch is missing. Thus on the body chamber only portions of the venter are visible. The complete ventral region is only preserved on the phragmocone.

Lindström's original illustration of this specimen is so crude and general that it would be extremely difficult, if not impossible, to identify this specimen with the drawing. A portion of the living chamber is missing leaving a wide gap; the remaining piece of the body chamber is crushed and has been glued into place. Lindström's drawing does not include this adoral portion of the living chamber. The illustrations in Mojsisovics (1886, pl. 6, figs. 8a-c) are superior but highly idealized. For instance, the view of the best preserved side (Fig. 8a) shows the body chamber completely reconstructed with no indication of the crushing or the piece that is missing. The view of the opposite side of the conch is a more faithful reproduction of what the specimen actually shows except that the missing segment of the body chamber is not indicated. The front view (Fig. 8c) is reasonably accurate for the portion covering the phragmocone but the cross-section of the living chamber is entirely reconstructed.

The inner whorls of the specimen, encompassing most of the phragmocone, are compressed, discoidal, with briefly arched lateral areas and a well rounded venter. At a diameter of 49 mm. the umbilicus measures 5.5 mm. in diameter. The umbilical shoulder is sharply rounded and, as far as can be told, the umbilical walls are nearly vertical. There is a trace of the umbilical seam for a half whorl beyond the phragmocone and this shows that the conch is gradually becoming more evolute and the umbilical diameter increasing. However, the umbilical shoulder is not preserved beyond a conch diameter of 49 mm. Ornamentation consists of weak radial to slightly sinuous growth lines plus weak strigations which are visible in the region of the venter. The suture of this specimen is reproduced here on Figure 2B.

This specimen came from the *Posidonomya* beds at Midterhuk, Spitsbergen. Mojsisovics (1886, p. 30) states that he had three specimens for study from Midterhuk, the locality of the type specimen, and from Isfjord-Kolonie, Spitsbergen.

Repository. Holotype, NRPAS[1] 247.

Ceratites polaris Mojsisovics (1886, pp. 31-32, pl. 7, figs. 1-2; Pl. 4, figs. 1, 2 of this report).

Hyatt (1900, p. 559) introduced the generic name *Arctoceras* for the group of *Ceratites polaris* Mojsisovics (1886). Later, Diener (1915, p. 52) designated the specimen figured by Mojsisovics (1886, pl. 7, figs. 1a, b) as the holotype. This particular specimen had previously been described and illustrated as *Ceratites blomstrandi* Lindström by Oberg (1877, p. 11, pl. 3, fig. 3).

The holotype is a specimen of approximately 51 mm. in diameter with a quarter whorl of body chamber. Only one side of the conch is preserved, the other side is completely missing and the venter preserved only in two small areas. The body chamber is likewise slightly crushed. Of the two illustrations that have

[1] Naturh. Riksmus. Paleozool. Avd. Stockholm.

previously been published of this species, that in Öberg (1877, pl. 3, fig. 3) is actually the best even though slightly idealized. It shows the matrix attached to a part of the specimen and general shape and involution of the conch. It does not, however, give a correct impression of the crushed nature of the body chamber or of the suture. The illustration in Mojsisovics (1886, pl. 7, figs. 1a-b) is a completely idealized drawing having little reality with the type specimen.

The conch is discoidal, compressed, with broad, slightly convex lateral areas, rounded ventral shoulders and somewhat narrowly rounded venter. The umbilical shoulders are sharply rounded and the umbilical wall nearly vertical. At a diameter of 44.5 mm. the whorl height is 23.6 mm. and the umbilical diameter 5.0 mm. The lateral areas bear sigmoidal striae of growth. The suture (Fig. 2A) consists of a large first lateral lobe with four denticulations and a smaller, narrow, second lateral lobe with only two denticulations.

The paratype (Mojsisovics, 1886, pl. 7, fig. 2; Pl. 4, fig. 2, of this report) is another specimen whose preservation leaves much to be desired. It consists of slightly more than half the conch — mostly phragmocone — and only one side of the specimen is preserved. Much of the specimen is covered by minute crystals of pyrite. The umbilical region is covered by matrix. The flanks are broad and nearly flattened, the ventral shoulders rounded and the venter arched. The suture is like that of the holotype and is reproduced here on Figure 3C.

Mojsisovics had four specimens for study from the *Posidonomya* beds at Isfjord-Kolonie, Spitsbergen.

Repository. Holotype NRPAS 270, paratype NRPAS 271.

Ceratites simplex Mojsisovics (1886, pp. 30-31, pl. 6, figs. 2-4; Pl. 5, figs. 1-8, of this report).

The three specimens illustrated by Mojsisovics (one only by its suture) plus the specimen assigned by Öberg (1877, p. 11, pl. 3, figs. 4a-c) to *Ceratites blomstrandi*, but included in *C. simplex* by Mojsisovics are available. They are all small, involute, discoidal forms of fair preservation. The illustrations of these specimens by Mojsisovics (1886) and Öberg (1877) are reasonably correct. The measurements of these four specimens are as follows:

	D	W	H	U
		(in mm.)		
Mojsisovics (1886, pl. 6, figs. 3a-b)				
NRPAS 273b	26.3	7.5	13.9	4.5

Öberg (1877, pl. 3, figs. 4a-c)				
NRPAS 278 (lectotype)	25.0	6.5	12.6	4.2
Mojsisovics (1886, pl. 6, fig. 4)				
NRPAS 273c	18.8	5.2	9.8	3.3
Mojsisovics (1886, pl. 6, figs. 2a-b)				
NRPAS 273a	16.3	4.2	9.0	2.3

The lateral flanks are broad and only slightly convex, being bounded by a well rounded ventral shoulder which grades onto a narrowly rounded venter; on the other extreme, the umbilical shoulders are sharply rounded and the umbilical wall nearly vertical. The venter is distinctly more flattened on specimen NRPAS 273a (Mojsisovics, 1886, pl. 6, figs. 2a-b) than on the other specimens producing a more distinct ventral shoulder somewhat resembling the umbilical shoulder.

The lateral areas have weak sinuous growth lines that are periodically accentuated in the dorsal half of the whorl sides. This feature is especially marked on the two larger specimens but barely visible on the two smaller specimens.

Mojsisovics (1886, p. 31) states he had nine specimens for study from the *Posidonomya* beds at Isfjord-Kolonie, Spitsbergen.

Repository. NRPAS 273a, b, c; 278 (lectotype).

Ceratites whitei Mojsisovics (1886, pp. 32-33, pl. 6, figs. 5-6; Pl. 3, figs. 3-4, Pl. 6, fig. 2, of this report).

The holotype and paratype of this species are available for study. The illustrations of these specimens in Mojsisovics' monograph (1886, pl. 6, figs. 5-6) are highly idealized drawings that give no idea of the actual poor preservation of the specimens.

The holotype consists of approximately two-thirds of a volution with the whole umbilical region missing (Pl. 3, figs. 3, 4). The ventral region and half of one flank of the adoral half of the specimen is also not preserved. The cross-section of the whorls is slightly inflated with convex lateral areas, rounded ventral shoulders and sharply rounded umbilical shoulders, and nearly vertical umbilical walls; the whorl section at the most adoral part of the specimen measures 15.4 mm. in width and 24.3 mm. in height. The lateral areas bear low, narrow radial folds that project slightly forward near the ventral shoulders.

The paratype is a small specimen of 36.7 mm. in diameter in which only one side of the conch is preserved and the umbilical region is filled with matrix. The lateral area of the adoral half whorl is crushed. Surface markings are not apparent on the conch, most likely due to the poor preservation of the specimen.

Mojsisovics' two specimens came from the *Posidonomya* beds at Isfjord-Kolonie, Spitsbergen.

Repository. Holotype NRPAS 280, paratype NRPAS 281.

Ceratites öbergi (Mojsisovics) (1882, p. 12; 1886, pp. 33-34, pl. 7, figs. 5-6; pl. 8, figs. 1, 3; pl. 2, figs. 1-2, pl. 3, fig. 5, pl. 4, fig. 3; Pl. 5, fig. 10, of this report).

The four specimens of this species described and figured by Mojsisovics (1886) are available for study. The holotype was designated by Mojsisovics (1882, p. 12) as the large specimen described and illustrated by Öberg (1877, pl. 3, figs. 1a-b; and pl. 8, figs. 3a-b in Mojsisovics, 1886) and thus cannot be the specimen illustrated by Oberg (1877 on pl. 3, figs. 2a-b and in Mojsisovics, 1886, on pl. 7, figs. 3a-b) as indicated by Spath (1934, p. 261).

The illustrations of the holotype in both Öberg (1877) and in Mojsisovics (1886) are fair representations of the specimen, that in Oberg's paper being the better. Neither of these authors shows any portion of the whorl broken off and it may be that a piece of the outer volution was broken off and lost since these authors studied the specimen.

The holotype consists of a fairly well preserved specimen of roughly 116 mm. in diameter of which only the venter and one side of the conch is preserved. The shell is present on most of the specimen except for a small part of the phragmocone. The whorl section has flattened sides, a broadly arched venter, well rounded ventral shoulder, and sharply rounded umbilical shoulder. The conch is evolute, the umbilicus measuring 29 mm. in diameter at the most adoral part of the conch. The umbilical walls are flattened and nearly vertical. The shell bears prominent, slightly sinuous folds or ribs that begin at the umbilical shoulder at a node or tubercle and end on the ventral shoulders. Parallel to the folds are fine growth lines. In addition to these features of ornament the shell on the venter and on the ventral half of the whorl sides bears fine strigations. The suture is reproduced on Figure 2C.

One of the paratypes (Pl. 4, fig. 3) is another of the specimens which Oberg (1877, pp. 11-13, pl. 3, figs. 2a-b) originally assigned to *Ceratites blomstrandi* Lindström. This is a fairly well preserved specimen in which only one side of the conch and the venter are preserved. The specimen measures 71.7 mm. in diameter, approximately 20 mm. for the width of the last whorl, 32.9 mm. for the height of the last whorl and the diameter of the umbilicus is 15.0 mm. The whorl section has the same general shape and features as the holotype. The whorls bear fine sinuous growth lines that are slightly enlarged on the umbilical shoulders forming incipient nodes. On the adoral first centimeter of the umbilical shoulder three prominent tubercles are present, each progressively larger than the preceding one. Slightly sinuous folds or ribs are widely spaced on the inner whorls, then for a half whorl appear to be absent, and finally reappear on the last quarter whorl of the specimen. The suture is reproduced here on Figure 3D.

The third specimen figured by Mojsisovics (1886, pl. 8, fig. 1) is a poorly preserved specimen of roughly half a whorl and really showing well only the umbilical region. Mojsisovics' illustration is highly idealized. The specimen displays the umbilical tubercles and the fine growth lines very well (Pl. 3, fig. 5).

The fourth specimen is a small form of approximately 33 mm. in diameter, embedded in matrix with only one side of the conch exposed. The umbilical shoulder is acutely rounded but no tubercles are present. The whorl sides have very weak, fine, slightly sinuous ribs.

Mojsisovics (1886, p. 34) had for study ten specimens which he assigned to this species which came from the *Posidonomya* beds at Isfjord-Kolonie, Spitsbergen.

Repository. Holotype NRPAS 289, paratypes NRPAS 286, 288, 284.

Ceratites lindströmi Mojsisovics (1886, p. 35, pl. 8, fig. 2; Pl. 7, fig. 1 of this report).

Mojsisovics based this species on a single large specimen of fair preservation in which only one side of the conch is preserved to about the mid-line of the venter. The specimen measures 110 mm. in diameter, 48.6 mm. for the height of the last whorl, and the umbilicus is 26 mm. in diameter. The shell is preserved only in a few small patches. The principal features of the conch are the rather closely spaced slightly sinuous ribs on the whorl sides. On the cast no umbilical tubercles are present but a small piece of shell is preserved on a portion of the umbilical shoulder and there the ribs are slightly enlarged to form a weak elongate tubercle. The inner whorls are very badly preserved but as far as can be told they appear to be smooth, lacking any type of ribs or folds. This, however, may be due to the preservation. The suture is reproduced here on Figure 3B.

Mojsisovics' holotype, and only specimen, came from the *Posidonomya* beds at Isfjord-Kolonie, Spitsbergen.

Repository. NRPAS 266.

Ceratites costatus Öberg (1877, pp. 13-14, fig. 3; Mojsisovics, 1886, pp. 36-37, pl. 7, figs. 3; Pl. 4, fig. 4, of this report).

The holotype and only specimen of this species is a cast, with no shell preserved, of only fair preservation. The specimen measures 77 mm. in diameter, 31.3 mm. for the height of the last whorl, and the umbilicus approximately 22 mm. in diameter. The most conspicuous features of this specimen are the rather prominent, slightly sinuous ribs. On all but the most adoral quarter whorl the ribs are most prominent on the dorsal half of the whorl side but, at least on the cast, do not form a tubercle at the umbilical shoulder. These ribs likewise disappear at the ventral shoulders. On the adoral quarter whorl the ribs are less prominent near the umbilical shoulder and gradually increase in size towards the venter. These ribs completely cross the venter where they are slightly projected forward. The region of the venter just adoral to each of these ribs is broadly constricted. The suture is reproduced here on Figure 3A.

The holotype is from the *Posidonomya* beds at Isfjord-Kolonie, Spitsbergen.

Repository. NRPAS 251.

Ceratites ind. Mojsisovics (1886. p. 32, pl. 6, fig. 7; Pl. 3, fig. 2, of this report).

This small specimen of mediocre preservation was left undetermined by Mojsisovics because the suture is not exposed. The specimen measures approximately 42 mm. in diameter and only one side of the specimen is preserved. The adoral quarter whorl is crushed and the umbilicus occupied mostly by matrix. The lateral areas are broadly arched and the venter narrowly rounded. The umbilical shoulders are sharply rounded and it appears that the umbilical walls are nearly vertical. Sinuous striae of growth are the only markings on the lateral areas.

The figured specimen came from the *Posidonomya* beds at Isfjord-Kolonie, Spitsbergen.

Repository. NRPAS 294.

Ceratites nov. f. indet. Mojsisovics (1886, p. 37, pl. 7, fig. 4; Öberg, 1877, p. 14, pl. 4, fig. 1c; Pl. 6, fig. 1 of this report).

This specimen is so poorly preserved one wonders why it was described at all by Mojsisovics and Öberg. No part of the shell is preserved and the internal cast is imperfect. All of the internal volutions are missing and a half of the outer whorl of phragmocone. Mojsisovics' (1886, pl. 7, fig. 4) illustration is highly idealized.

The most significant feature of this specimen is the rounded umbilical shoulder, and in this feature, plus faint ribs on the living chamber, it shows some similarity to *A. costatum*. The umbilical shoulder is preserved, however, only on the living chamber and in the absence of any shell, care is needed in the interpretation of this feature.

The specimen came from the *Posidonomya* beds, Isfjord-Kolonie, Spitsbergen.

Repository. NRPAS 293.

Remarks.

The primary types of all the various species of *Arctoceras* represent different growth stages of a single species which shows marked variability in its ontogeny. *Arctoceras simplex* (Mojsisovics) was established for the smallest specimens. In addition to the three specimens described and illustrated by Mojsisovics (1886, pp. 30-31, pl. 6, figs. 2-4), he also included in this species a similar small involute form which Öberg (1877, p. 11, pl. 3, fig. 4) had identified as the inner whorls of *Ceratites blomstrandi*. All four of these specimens are involute, compressed forms with broadly convex flanks. The smallest specimen (Pl. 5, figs. 5, 6) has just the faintest trace of radial ornamentation and the ventral shoulders are abruptly rounded and the venter only slightly arched. The two larger specimens of *Ceratites simplex* (Pl. 5, figs. 1, 2, 7, 8) have low, but clearly marked, slightly sinuous ribs that begin at the umbilical shoulder and disappear as they approach the venter. The venter is also more highly arched. This basic conch plan is maintained at a diameter of 31 mm. as illustrated on the specimen of Plate 5, figure 9: it also characterizes the following specimens: the paratype of *Ceratites whitei* (Pl. 6, fig. 2) — diameter 37 mm. — which has a slightly larger umbilicus; the specimen Mojsisovics listed as *Ceratites* ind. (Pl. 3, fig. 2); the inner whorls of the holotype of *Ceratites blomstrandi* (Pl. 1, fig. 2); the plesiotype of Plate 3, figure 1; and the holotype of *Ceratites polaris* (Pl. 4. fig. 1). At its diameter, the whorls of the holotype of *Ceratites whitei* are a little more inflated and the ribs more conspicuous. Above a diameter of approximately 50 mm., there is an even greater degree of variation in conch shape and ornamentation. On the one hand, there are forms of 69 mm. in diameter (Pl. 6, fig. 4) which maintain the pattern of the youthful forms except that the umbilicus becomes broader and deeper. Ornamentation consists of narrow, closely spaced ribs or bunched growth lines. The umbilical slope is not quite vertical and the umbilical shoulder sharply rounded but lacking nodes. Somewhat similar conch pattern is displayed by the paratype of *Ceratites blomstrandi* (Pl. 1, figs. 3, 4) except that in this specimen the umbilical shoulder is more sharply rounded, the sinuous lateral ribs more prominent and the ribs are slightly enlarged at the umbilical shoulder. The paratype of *Ceratites öbergi* (Pl. 4, fig. 3) is also quite similar but on this specimen the umbilical wall is vertical and nodes are apparent on the most adoral part of the umbilical shoulder. The nodes on the other paratype of *Ceratites öbergi* (Pl. 3, fig. 5) appear earlier and are more conspicuous. These latter forms grade into the type of conch of the large holotype of *Ceratites öbergi* (Pl. 2, figs. 1, 2).

Ceratites costatus (Pl. 4, fig. 4) is quite distinctive in its larger umbilicus and coarser lateral ribs which cross the venter on the most adoral quarter whorl. None of the shell is preserved on this specimen. The large, poorly preserved specimen which represents the holotype of *Ceratites lindströmi* (Pl. 7, fig. 1) also has prominent coarse lateral ribs such as those in *Ceratites öbergi*. The venter of the adoral half whorl of this specimen is not preserved but there is a suggestion that the ribs do cross the venter. The portion of the inner whorls that is visible is without ribs.

Discrimination of the various species of *Arctoceras* on the basis of conch shape, degree of involution, etc. was attempted by earlier authors. On Figure 1, are plotted the measurements of the height of last whorl and umbilical diameter of 202 specimens of *Arctoceras* from Spitsbergen, identified by L. F. Spath, in the British Museum (Natural History). This includes 141 specimens of *A. blomstrandi*, 41 specimens of *A. whitei*, 11 specimens of *A. polare*, 8 specimens of *A. costatum*, and 1 specimen of *A. öbergi*. In addition, the numbered points are for thirteen primary types of the various species of *Arctoceras*. The range of variation within each of the "so-called" species is roughly the same and these ranges overlap one another. Nor are any significant differences apparent between the various growth stages. It is not possible on the basis of these two measurements to differentiate the seven species of *Arctoceras* previously recognized; the data supports the conclusion that this is a single species complex.

Additional data on the degree and kind of ornamentation on the 202 specimens in the British Museum (Natural History) are not available. However, from a study of the primary types, the differences in ornamentation are merely a matter of degree and merely a matter of the stage of ontogenetical development of the particular specimen. The ribbing ranges from fine to coarse, narrow to broad, and appears at varying times in the development of the conch. Spath's (1934) description of some of the Spitsbergen arctoceratids repeatedly emphasizes the gradational nature of conch form and ornamentation between all the various species.

The suture was one of the primary features Mojsisovics used to differentiate his various species. The suture of each of the seven primary types is illustrated on Figures 2 and 3. The number of denticulations on the lobes, the shape of the lobes, etc. are hardly proper criteria for separation of species in forms like this that occur in the same place and geological horizon Spath (1934, p. 262) records a specimen of *A. öbergi* in which the number of denticulations in the lobes varies on opposite sides of the same individual. It was criteria such as this — the number of denticulations of the lobes — that Mojsisovics used to distinguish some of his species. The differences in the sutures as shown in Figures 2 and 3 are due to differences in the growth stage at which the suture was taken or are merely the normal variations one should expect in a variable population.

The most closely related species to these Spitsbergen arctoceratids are forms from the Arctic islands of Canada which Tozer (personal communication) is placing in *Arctoceras öbergi*. In addition, *Meekoceras tuberculatum* Smith (1932) is remarkably similar. Smith based his species on two highly deformed specimens from the *Meekoceras* beds, Union Wash, Inyo Range, California (Pl. 8, figs. 1, 2). The writer has in press a study of a large, excellently preserved *Meekoceras* fauna from Elko County, northeastern Nevada. This fauna has yielded a number of well preserved specimens which are conspecific with *Meekoceras tuberculatum*. Study of these specimens has given a better appreciation of the amount and kind of variation to be found in species of this conch morphology.

In these Nevada specimens the conch is evolute with slightly convex, broad lateral areas and a broadly rounded venter (Pls. 8, 9). The ventral shoulders are rounded, grading imperceptibly onto the venter and the flanks of the whorl section. The umbilical shoulders are sharply rounded and conspicuous, the umbilical walls flat and nearly vertical. The most characteristic features of this species are the nodes on the umbilical shoulders. The nodes are spaced roughly 10 mm. apart along the umbilical shoulder and appear to vary considerably in size. In addition to these nodes, the conch bears radial folds on the flanks which likewise show great variation in strength and numbers. Some forms have prominent radial ribs, widely spaced, others have less prominent but closely spaced ribs. Other forms appear to be almost smooth but with weak, low, broad folds. On the better preserved specimens, weak strigations are visible. Juvenile specimens up to a diameter of at least 40 mm. have no ornamentation, lacking the radial folds and the umbilical tubercles.

The height of the whorl section and the diameter of the umbilicus for thirteen specimens are plotted on Figure 4.

The suture has a broad denticulated ventral lobe, a relatively narrow, long, first lateral lobe, a narrow, short, second lateral lobe and a short differentiated auxiliary series; the first lateral saddle is broad and rounded, the second lateral saddle is equally rounded but not so broad (Fig. 5A). The suture of juvenile forms (25 mm. in diameter) in contrast to the more mature suture has relatively narrow phylloid saddles (Fig. 5C) but the saddles change rapidly into broad, rounded forms. The suture of Smith's holotype and that of a paratype are reproduced here on Figure 5D, E; that of the holotype is nearly identical to the Crittenden Spring specimen except for slight differences in the pattern of denticulations of the second lateral lobe and in the auxiliary series. The suture of the paratype as drawn by Smith has denticulations extending half way up the sides of the lobes. The fact that the Inyo Range specimens are so deformed opens the question as to whether this particular pattern is not a reflection of distortion rather than the true pattern.

The suture of *Arctoceras tuberculatum* is of the same basic plan as that of *Arctoceras blomstrandi.* Separation of these forms into distinct genera, as advocated by Spath (1934) on the basis of differences in the suture, especially the saddles, is untenable. The immature suture of *A. tuberculatum* does have saddles quite distinct from sutures of specimens of comparable size of *A. blomstrandi.* It is on the basis of the suture up to a diameter of roughly 30 mm. and the slightly greater inflation of the conch at this size that *A. tuberculatum* is kept distinct from *A. blomstrandi.* I do not believe that these two species could be differentiated without data on the inner whorls.

The Age of the *Arctoceras* Fauna

With this analysis of the Spitsbergen arctoceratids it seems appropriate to comment briefly on the stratigraphic position of the *Arctoceras* fauna and associated Lower Triassic faunas of Spitsbergen. For much of the recent stratigraphical and paleontological work on the Triassic of this area we look to the fine publications of Frebold (1929a, 1930, 1931, 1939); Spath (1921, 1934) has also commented extensively on the ammonoids of Spitsbergen and their stratigraphic relationships.

The early Scythian of Spitsbergen is represented mainly by pelecypods (*Myalina, Anodontophora, Gervilleia, Eumorphotis, Aviculopecten*), a few brachiopods (*Terebratula, Retzia, Orbiculoidea*), a bellerophon, and indeterminate ammonoids (Frebold, 1939). The lowest horizon that contains an identifiable ammonoid fauna is the *Posidonomya* Beds (or Fish-horizon, see Frebold, 1930, p. 31) and most of the Lower Triassic ammonoids from Spitsbergen have come from this stratigraphic unit. Frebold (1930) came to the conclusion that there were two distinct ammonoid faunas in the *Posidonomya* Beds, a lower and an upper. The lower ammonoid fauna contains the following species (Frebold, 1930; Spath, 1921, 1934):

Arctoprionites nodosus (Frebold)
Arctoprionites tyrelli Spath
Arctoprionites n. sp.
Xenoceltites subevolutus Spath
Xenoceltites gregoryi Spath
Xenoceltites spitsbergensis Spath
Hemiprionites garwoodi Spath
Gurleyites freboldi Spath
Wasatchites tridentinus Spath

The ammonoid fauna of the upper part of the *Posidonomya* Beds is characterized by the following species:

Arctoceras blomstrandi (Lindström)
Prosphingites spathi Frebold
Tellerites oxynotum Frebold
Tellerites furcatus (Oberg)
"Meekoceras"? cf. keyserlingi Mojsisovics
Pseudosageceras grippi Frebold

Frebold (1930) concluded that the lower fauna was equivalent to that of the Ceratite sandstone of the Salt Range, Pakistan (*Flemingites flemingianus* zone) and in part to the *Hedenstroemia* beds of the Himalayas. The upper fauna Frebold considered as equivalent in part to the fauna of the Olenek Beds, Siberia, and to the *Columbites* fauna of southeastern Idaho. Spath (1934) listed many of the species in the lower fauna as upper Owenitan (*Anasibirites* zone) in age but the various species of *Xenoceltites* and other forms he placed in his Columbitan division with a question mark. The upper fauna was listed as Columbitan in age with question, presumably suggesting the possibility of it being younger (Spath, 1934, pp. 257, 258).

The genera of the lower fauna are all forms typical of *Anasibirites* faunas throughout the world, even though the name genus *Anasibirites* does not appear to be present. The *Anasibirites* fauna has been recognized in Utah (Mathews, 1929), Idaho (Kummel, 1954), British Columbia (McLearn, 1945), Queen Elizabeth Islands (Tozer, 1958), Shikoku, Japan (Yehara, 1928), Hupeh, China (Tien, 1933), Kiangsu, China (Hsu, 1936), Timor (Welter, 1922), Salt Range, Pakistan (Waagen, 1895), and at Byans in the Himalayas (Krafft and Diener, 1909). Spath (1921) tentatively assigned some of his Spitsbergen specimens to *Anasibirites* but later (Spath, 1934, p. 346) he commented as follows on these specimens: "The Spitsbergen forms are now included in *Arctoprionites*, since they are connected by transitions with the other forms of that new genus, but they might perhaps have been left in *Anasibirites*, like the equally discoidal and "*Meekoceras*"-like *A. multiformis*, form VIII (Welter, 1922, pl. clxxi, figs. 8-10), or some of v. Krafft's incompletely known Himalayan species."

Arctoprionites — type species, *Goniodiscus nodosus* Frebold (1930, pp. 8-11, pl. 1, figs. 6-7; pl. 2, fig. 2) — was established for a small group of species from Spitsbergen. It is a prionitid with a discoidal conch, a tabulate venter and bearing costations or tuberculations on the whorl sides. No other species, than those from Spitsbergen, were assigned to this genus by Spath. The writer has a single, well preserved, though incomplete specimen from the *Meekoceras* zone near Montello, Nevada, which will be described in a paper now in press. The form described by McLearn (1945) as "*Prionites*" *hollandi* most likely belongs to this genus, even though, as remarked by that author, the tubercles are closer to the umbilical shoulder and the venter is not as tabulate as in *Arctoprionites*. The specimen described by Diener (1913) as *Flemingites* (?) sp. ind. aff. *muthensis* Krafft, from Kashmir, is also most probably a species of *Arctoprionites*.

Hemiprionites has a very widespread distribution. Species of this genus are known from the Upper Ceratite Limestone of the Salt Range (Waagen, 1895), the *Anasibirites* beds of Timor (Welter, 1922), the *Anasibirites* fauna on Shikoku, Japan (Yehara, 1928), the *Anasibirites* zone near Fort Douglas, Utah (Mathews, 1929), the *Anasibirites* zone near Georgetown, southeastern Idaho (Kummel, 1954), and from the *Anasibirites* fauna in the Toad formation, along the Liard River, British Columbia (McLearn, 1945).

Gurleyites is known from the *Anasibirites* fauna of Fort Douglas, Utah (Mathews, 1929), near Georgetown, southeastern Idaho (Kummel, 1954), and from the lower fauna of the *Posidonomya* Beds of Spitsbergen (Frebold, 1930; Spath, 1934).

Wasatchites is likewise known from typical *Anasibirites* faunas in Utah, Idaho, British Columbia, Queen Elizabeth Islands, Timor, and in Spitsbergen.

Of the original fauna from Spitsbergen studied by Spath (1921) the largest single taxon consisted of specimens which were regarded as an unnamed group for which he later (Spath, 1930, pp. 12, 90) proposed the generic name *Xenoceltites* — type species, *Xenoceltites subevolutus* Spath = *Xenodiscus* cf. *comptoni* (non Diener), Frebold, 1930, p. 14, pl. 3, fig. 1 (lectotype), 2, 3. Spath also recognized congeneric species in the *Anasibirites* fauna of Fort Douglas, Utah, and in the fauna from the Ussuri Bay region described by Diener (1895). Kiparisova (1945) reports unnamed species of *Xenoceltites* from the south Ussuri region (near Vladivostok) in approximately mid-Scythian horizons. McLearn (1945) has also described two species of *Xenoceltites* from the *Anasibirites* zone of British Columbia.

Spath (1934) came to the conclusion that all of the various *Anasibirites* faunas were not contemporaneous and that the Spitsbergen fauna, for example, was probably slightly younger than that from Utah. For my own part, there does not seem to be any real justification for this conclusion. At a generic level all of these *Anasibirites* faunas are remarkably similar. *Hemiprionites, Gurleyites,* and *Wasatchites* are known only from this zone. *Arctoprionites* and *Anasibirites* appear to range from the *Meekoceras* zone to the *Anasibirites* zone. *Xenoceltites* appears to be mainly confined to this zone but it is likely that it ranges lower and higher in the Scythian.

The age of the *Arctoceras* fauna from Spitsbergen is much more difficult to assess. Frebold (1930) considered this fauna to be approximately equivalent to the Olenek fauna of Siberia and to the *Columbites* fauna of southeastern Idaho. Spath (1934) classified the *Arctoceras* fauna as belonging to his Columbitan division with question, suggesting that it was younger than the *Columbites* fauna of Idaho. The fauna comprises only four species in addition to the name-giving *Arctoceras blomstrandi*. These additional species are, however, not as helpful in the dating problem as one could wish. *Tellerites* is as yet incompletely known, that is, few specimens have been found and all of these are small specimens which possibly could represent immature forms. The occluded, compressed conch with the narrow, channeled venter is quite unlike any other Lower Triassic ammonoid. *Tellerites oxynotum* Frebold (1930, pp. 22-23, pl. 4, fig. 4) is also most probably not congeneric with *T. furcatum* (Öberg). Likewise, the form assigned by Frebold (1929b) to *Pseudosageceras grippi* could possibly be a *Tellerites*. The form assigned by Frebold (1930, p. 18) to *Meekoceras* cf. *keyserlingi* Mojsisovics lacks the suture. Whereas the Spitsbergen specimen does resemble the Olenek specimen, there is such homeomorphy among middle and upper Scythian ammonoids of this morphology that without the suture and an abundance of material this identification can only be looked upon as tentative. This leaves only *Prosphingites spathi* and *Arctoceras blomstrandi* upon which one can establish some basis for an age assignment for the fauna.

The genotype of *Prosphingites* is *P. czekanowskii* Mojsisovics (1886, p. 64, pl. 15, fig. 10-12) from the region of the mouth of the Olenek River, Siberia. The inner whorls are globular but the outer whorls more compressed and the venter narrowly opened. The Spitsbergen species are unquestionably prosphingitids but differ from the type species in their more rounded and depressed whorl section at maturity. They are clearly a different species. At the time Spath published his catalogue (1934), he recognized *Prosphingites austini* (Hyatt and Smith, 1905, pp. 72, 73) from the zone of *Meekoceras gracilitatus* in California as most likely being the oldest known species. The genus is also present in the faunas of the *Prohungarites* zone from Albania (Arthaber, 1911), Chios (Renz and Renz, 1948) and Ussuri Bay of eastern Siberia (Kiparisova, 1947) but the species in these faunas are very distinct from those of either Spitsbergen or the Olenek River region. This left the range of *Prosphingites* as definitely including the upper part of the Scythian but only questionably extending as low as the zone of *Meekoceras gracilitatus.* The genus, however, is more widespread in the *Meekoceras* zone of Nevada and Idaho than has been suspected. The writer has in press a report on a large *Meekoceras* fauna of excellent preservation from Elko County, Nevada, that contains a large number of specimens assigned to a new species of *Prosphingites.* This clearly established that *Prosphingites* is well represented in the *Meekoceras gracilitatus* zone and extends upwards through the remainder of the Scythian. These Nevada specimens are more like the Spitsbergen *Prosphingites spathi* than the Olenek, *P. czekanowskii.* In previous analysis of the age of the *Arctoceras* fauna, the fact that the generic assignment of the California *Prosphingites austini* was open to question and the definitely identified prosphingitids came from horizons of the *Prohungarites* zone rightly had a strong influence in placing the *Arctoceras* fauna high in the Scythian.

More satisfactory results can be attained by analyzing *Arctoceras blomstrandi.* Spath (1934, p. 254) maintained that *Arctoceras* was quite distinct from *Submeekoceras* on the basis of its broader saddles. Restudy of the type specimens of the various "species" of *Arctoceras* from Spitsbergen fails to substantiate Spath's conclusion. The range of variation in the suture in both the American species of *Submeekoceras* and of the Spitsbergen *Arctoceras* preclude any attempt to differentiate them on the basis of the suture. The resemblance in both suture and conch morphology of the Spitsbergen *Arctoceras* to *Meekoceras tuberculatum* Smith (1932, p. 62, pl. 50, figs. 1-4) is indeed remarkable. Smith unfortunately based his species on a deformed specimen from the *Meekoceras* zone exposed in the Inyo Range, California. The new fauna of the *Meekoceras* zone from Elko County, Nevada, has numerous large examples of this same species and on direct comparison with the types of the Spitsbergen species of *Arctoceras,* the differences apparent are of no more than specific significance. The genus *Submeekoceras* Spath (1934, p. 255) should be suppressed in favor of *Arctoceras* Hyatt (1900, p. 559). Confirmation of this interpretation of *Arctoceras* has been established by Tozer (1958 and personal communication) from his studies of a splendid sequence of faunas in Triassic sections in the Queen Elizabeth Islands (mainly on Ellesmere and Axel Heiberg islands). One of the fifteen distinct faunas recognized by Tozer contains *Meekoceras, Arctoceras, Euflemingites, Pseudosageceras*, etc. What is most significant about this fauna is the presence in the same beds on Ellesmere Island of *Meekoceras gracilitatus* and *Arctoceras oebergi* (Tozer, personal communication). This fauna is overlain by faunas with *Wasatchites* and the latter by *Olenekites.*

From what we know of the *Arctoceras* fauna at the moment, it shows more affinity with the fauna of the *Meekoceras* zone of western North America than with other known Scythian fauna. However, if the Spitsbergen *Arctoceras* fauna occurs above a fauna of the *Anasibirites* zone as stated by Frebold it cannot be contemporaneous with the zone of *Meekoceras gracilitatus.* It appears to the writer, however, that it is more likely that the *Arctoceras* fauna is related to the faunas of the middle Scythian zones, the *Owenitan* of Spath (1934, p. 27) rather than to the higher Scythian zones comprising Spath's Columbitan and Prohungaritan divisions. The strong similarities of both the *Arctoceras* and *Anasibirites* faunas of Spitsbergen to the *Meekoceras* and *Anasibirites* faunas of western United States (and northern Canada) forces one to question whether the faunal sequence of the *Posidonomya* beds of Spitsbergen has been interpreted correctly. At least additional field observations are needed to clarify this issue. If Frebold's conclusion on the stratigraphic relations of these two faunas is correct, then the *Arctoceras* fauna most likely represents a new zone of Owenitan age, lying above the *Anasibirites* zone and below that of *Tirolites.* The remainder of this discussion is a review of the known upper Scythian ammonoid faunas of the world to demonstrate the impossibility of correlating the *Arctoceras* fauna with any zone other than those of Owenitan age.

One of the best areas of exposure of fossiliferous Scythian strata is to be found in southeastern Idaho. In this region the stratigraphy is well known (Kummel, 1954) and all three of the Upper Scythian ammonoid zones are represented. The *Tirolites* fauna is known only from Paris Canyon about 800 feet above the lower limestone member of the Thaynes formation that contains the *Meekoceras* fauna. Smith (1932) identified the following ammonoid species from this zone:

Dalmatites attenuatus Smith
Tirolites harti Smith
Tirolites knighti Smith
Tirolites pealei Smith

The *Columbites* fauna occurs in the middle shale unit of the Thaynes formation and it includes the following species (Smith, 1932; Kummel, 1954):

"*Ophiceras*" *jacksoni* Hyatt and Smith
"*Ophiceras*" *spencei* Hyatt and Smith
"*Meekoceras*" *curticostatum* Smith
"*Meekoceras*" *micromphalus* Smith
"*Meekoceras*" *pilatum* Hyatt and Smith
"*Meekoceras*" *sanctorum* Smith
Hellenites idahoense (Smith)
Tirolites cf. *T. illyricus* Mojsisovics
Pseudosageceras multilobatum Noetling
"*Celtites*" *apostolicus* Smith
"*Celtites*" *planovolvis* Smith
"*Celtites*" *ursensis* Smith
Columbites consanguineus Smith
Columbites ligatus Smith
Columbites minimum Smith
Columbites ornatus Smith
Columbites parisianus Hyatt and Smith

Finally, the *Prohungarites* fauna occurs approximately 1000 feet above the *Columbites* beds. In this fauna the following species have been identified (Kummel, 1954).

Prohungarites n. sp. cf. *P. similis* Spath
Prohungarites n. sp. cf. *P. crasseplicatus* (Welter)
Svalbardiceras sp.
Metahedenstroemia n. sp.
Keyserlingites n. sp. cf. *K. subrobustus* (Mojsisovics)
Isculitoides n. sp.
Epiceltites n. sp. cf. *E. genti* Arthaber
Czekanowskites ? sp.
Stacheites sp.
Olenekites ? sp.

Since this Idaho succession is in general more complete in terms of the faunas present and the stratigraphic data it will be used in this discussion as a standard of reference.

Each of these faunas is quite distinct from the *Arctoceras* fauna of Spitsbergen; in fact, there is really not a single genus in common between these Idaho faunas and the Spitsbergen fauna. The extremely important faunas being studied by Tozer (1958) from the Queen Elizabeth Islands include the *Meekoceras* fauna (containing *Arctoceras*), the *Wasatchites* fauna (= *Anasibirites* zone), and the *Olenekites* fauna (= *Prohungarites* zone). Note that here *Arctoceras* is associated with the *Meekoceras* fauna and that from the data available there is nothing in the two other faunas to show any affinities with the *Arctoceras* fauna of Spitsbergen.

The Siberian coastal region around the lower parts of the Olenek and Lena Rivers has been well known to students of Triassic ammonoids through the monographs of Mojsisovics (1886, 1888). At the same time, the large Scythian fauna described by Mojsisovics from the lower Olenek River region has long been a source of controversy in respect to its age. Recently, Popov (1958) has published a valuable synthesis of the stratigraphy and faunal content of the Lower and Middle Triassic strata in this part of Siberia. The oldest Triassic strata known from this region are tuffaceous sandstones, shales, and tuffs that contain species of *Estheria* and plant remains. These strata are known from only two regions: the first is the Ulahan-Yuryak region in the lower part of the Lena River, and the second is the Pur River, a tributary entering the lower Olenek River from the west. In both regions these early Triassic deposits rest disconformably on Permian sandstones. Above this lower tuffaceous member in the Ulahan-Yuryak region are 60 meters of black shale with coquinoid beds of *Posidonia* sp., *Posidonia miner* Öberg, and *Glyptophiceras* (?) sp. ind. In the Pur-Olenek region the unit overlying the basal tuffaceous strata is composed of shales, sandstones, and marls with limestone concretions. Some of the sandstone beds contain abundant *Myalina* ex. gr. *schamarae* Bittner. The shale and marl beds contain, according to Popov (1958), *Paranorites oleneckensis* Kiparisova (*n. nudum*), *P.* aff. *oleneckensis* Kiparisova, *Clypeoceras gantmani* Kiparisova (*n. nudum*), *Glyptophiceras* (?) sp. ind., *Ophiceras Lytophiceras*) sp. ind., *Metophiceras* (?) sp., and *Hedenstroemia mojsisovicsi* Diener. Popov concluded that this fauna was mid-Scythian in age, equivalent to the *Hedenstroemia* beds of the Himalayas and the Salt Range. Evaluation of this fauna is difficult, because aside from *Hedenstroemia mojsisovicsi* none of the species have been described or illustrated. However, the presence of large *Hedenstroemia* and *Clypeoceras* certainly suggests a mid-Scythian age. Popov (1958) correlated these units with a horizon in the Okhotsk-Kolyma land that contains (Popov,

1939) *Pseudosageceras multilobatum* Noetling, *Anahedenstroemia tscherskii* Popov, *Paranannites globosus* Popov, *Ophiceras* (*Lytophiceras*) *subleptodiscus* Popov. At a later date Popov (1958) added *Hedenstroemia mojsisovicsi* to this faunal list. Popov correlated his fauna from the Okhotsk-Kolyma land with the *Meekoceras* beds of California and Nevada, the *Hedenstroemia* beds of the Himalayas, and the Upper Ceratite sandstone of the Salt Range, units which I do not believe are strictly contemporaneous. The *Hedenstroemia* beds of the Himalayas and the *Meekoceras* fauna of western United States are more likely contemporaneous but the Salt Range fauna may represent the next older zone.

Overlying the beds with mid-Scythian ammonoids are up to 200 meters of black shales and marls with concretions and green-gray sandstones. These beds contain the classic Olenek fauna described by Mojsisovics (1886, 1888). This fauna includes the following species:

Olenekites spiniplicatus (Mojsisovics)
Olenekites volutus (Mojsisovics)
Olenekites densiplicatus (Mojsisovics)
Olenekites altus (Mojsisovics)
Olenekites intermedius (Mojsisovics)
Olenekites laevis (Mojsisovics)
Olenekites sigmatoidus (Mojsisovics)
Xenoceltites glacialis (Mojsisovics)
Xenoceltites multiplicatus (Mojsisovics)
Xenoceltites hyperboreus (Mojsisovics)
Xenoceltites fissiplicatus (Mojsisovics)
Xenoceltites discretus (Mojsisovics)
Keyserlingites middendorffi (Keyserling)
Keyserlingites schrencki (Mojsisovics)
Keyserlingites subrobustus (Mojsisovics)
Czekanowskites decipiens (Mojsisovics)
Czekanowskites inostranzeffi (Mojsisovics)
Sibirites eichwaldi (Keyserling)
Sibirites pretiosus (Mojsisovics)
Arctoceras euomphalus (Keyserling)
Svalbardiceras schmidti (Mojsisovics)
"*Xenodiscus*" *dentosus* (Mojsisovics)
"*Xenodiscus*" *karpinskii* (Mojsisovics)
"*Meekoceras*" *keyserlingi* (Mojsisovics)
"*Meekoceras*" *rotundatum* (Mojsisovics)

"*Meekoceras*" *sibiricum* (Mojsisovics)
Prosphingites czekanowskii (Mojsisovics)
"*Popanoceras*" indet.

The age of this fauna has long been a source of debate but stratigraphic and paleontological studies in North America over the past decade have helped to clarify this problem immensely. The key to the understanding of the Olenek fauna is the sequence of faunas in southeastern Idaho where the uppermost ammonoid zone contains *Olenekites, Czekanowskites, Keyserlingites,* and *Svalbardiceras.* The first two of these genera are represented by poorly preserved specimens and there was at first some question as to these identifications. The *Prohungarites similis* fauna of southeastern Idaho represents a mixture of the boreal Olenek fauna and the Tethyan Albania-Chios-Timor faunas. A similar fauna, of splendid preservation (including *Olenekites*), is known from the Tobin formation of Nevada (S. W. Muller, personal communication). Likewise Tozer (1958) reports *Olenekites* at the top of the Scythian sequence in the Arctic islands of Canada. There is no question but that Spath (1934) was correct in placing the Olenek fauna high in the Scythian, above the zone of *Columbites parisianus.*

The *Arctoceras* fauna of Spitsbergen has in common with the Olenek fauna: *Prosphingites, Arctoceras,* and the doubtful "*Meekoceras*" cf. *keyserlingi. Prosphingites* is a long-ranging genus and the Spitsbergen and Olenek species are quite different. The arctocerid *A. euomphalus* (which Mojsisovics, 1886, originally placed in *Xenodiscus*) represents a morphological type that occurred repeatedly in the Upper Scythian. It would be inadvisable to place any credence on this form for purposes of correlation. As mentioned earlier, the identification of "*Meekoceras*" cf. *keyserlingi* from Spitsbergen is open to question. There does not seem to be any basis whatsoever on which to compare directly the *Arctoceras* fauna of Spitsbergen and the Olenek fauna of Siberia; this is due, in my opinion, to their complete difference in age.

Extensive outcrops of Lower Triassic strata in the south Ussuri coastal region around Vladivostok have attracted the attention of numerous Triassic students ever since Diener (1895) first monographed the ammonites from this region. In addition to ammonites, these strata contain a rich and diverse fauna of pelecypods which have been monographed by Kiparisova (1938). The stratigraphy of these Lower Triassic formations has been summarized by Kiparisova (1945), who recognized four main beds which, from bottom to top, she referred to as (a) the Basal bed, (b) *Meekoceras* beds, (c) *Flemingites* beds, and (d) the *Subcolumbites* beds. Only the two upper units need concern us here. Most of the species listed by Kiparisova in her 1945 paper were *nomina nuda* and were not formally described until 1947.

The *Flemingites* beds consist of thin bedded sandstones containing *Flemingites prynadi* Kiparisova (1947), *Proptychites latifimbriatus* (de Koninck) Kiparisova (1947) plus a large fauna of small pelecypods. This horizon Kiparisova correlated with the Ceratite sandstone of the Salt Range, the *Hedenstroemia* beds of the Himalayas and the *Meekoceras* zone of western North America — again, horizons which are probably not contemporaneous.

It appears that the thickness and aerial extent of the *Flemingites* beds are still unknown for in places it is only one meter thick. On the Russian Island the "*Meekoceras*" beds are overlain by thin-bedded sandstones alternating with clay shales. In the lower part of this sequence occurs *Tropiceltites inopinatus* Kiparisova (*n. nudum*). A limestone band 30-40 meters higher contains *Subcolumbites multiformis* Kiparisova (1947), *Prosphingites globosus* Kiparisova (1947), *Megaphyllites immaturus* Kiparisova (*n. nudum*), *Paranannites suboviformis* Kiparisova (*n. nudum*), *Paranannites gracilis* Kiparisova (1947), *Pseudosageceras simplex* Kiparisova (1947), *Grypoceras ussuriense* Kiparisova (1947), and *Orthoceras subcampanile* Kiparisova (*n. nudum*). This fauna Kiparisova correctly recognized as of uppermost Scythian age and representing the zone of *Prohungarites similis.*

The widespread occurrence of Lower Triassic formations in south China has long been known, but the lack of comprehensive stratigraphical and paleontological reports, especially on the ammonites, has handicapped interpretation of the record. The only monographic treatment of Lower Triassic ammonoids is by Tien (1933), and small but interesting faunas of ammonoids have been described by Hsu (1936, 1937). A monographic study of the Triassic fossils of Yunnan has apparently been prepared by T. H. Yen and T. Y. Hsu but has never been published (*fide* Hsu, 1937; Hsi-chih, 1947).

Among the faunas described by Tien (1933) was a single specimen from a locality in Kweichow, referred to *Palaeophyllites* cf. *steinmanni* Welter. Previously this particular species has been known only from the *Prohungarites similis* zone of Timor. However, Tien's specimen is quite different, and this suggested identification must be left in doubt.

In a comprehensive report on the Lower Triassic Chinglung limestone exposed in the lower Yangtze Valley around Nanking, Chi, Hsu, and Sheng (1936) recorded two distinct ammonoid zones. Specimens from these zones have been described by Hsu (1936). The lower fauna is of early Scythian age but the upper fauna was said to contain *Xenodiscus* sp., *Tirolites* cf. *spinosus* Mojsisovics, *Tirolites* sp. nov. ind., *Anasibirites* sp., and *Celtites* sp. Hsu (1936) interpreted these faunas as representing the *Anasibirites* and *Tirolites* zones; however, from the description and illustrations, the tirolitids and celtitids appear to belong to *Xenoceltites*. If this determination is correct, it appears unlikely that the *Tirolites* zone is represented.

What appears to be potentially the largest and zonally the most complete representation of Lower Triassic ammonoids in south China has been recorded by Chao (1947) from western Kwangsi. Aside from a statement that these faunas contain more than 60 genera, little is known except the illustrations and description of a few new genera (Chao, 1950).

The youngest Scythian ammonoid fauna known from Japan is that described by Yehara (1928) representing the *Anasibirites* zone.

The glamor of the beautifully preserved and diverse Scythian faunas from Timor is slightly tarnished by the lack of any stratigraphic data. As pointed out by Spath (1934, pp. 30, 31), the bulk of Welter's (1922) Scythian ammonoids belong to about the mid part of that stage, but one fauna, that from Block "E" bei Nifoekoko which Welter placed about equivalent to his *Owenites* limestone, Spath placed as at or near the top of the Scythian. The name genus of Spath's Prohungaritan division and the one zone assigned to this division was based on a species from Block "E" bei Nifoekoko. It is unfortunate that the name bearing specimens for this division and zone came from a unit on which no stratigraphic data whatsoever are available. The fauna from Block "E" bei Nifoekoko contains the following species:

Prenkites timorensis Spath
Eophyllites orientalis Spath
Palaeophyllites steinmanni Welter
Proptychitoides arthaberi (Welter)

Prohungarites similis Spath
Prohungarites crasseplicatus (Welter)
Prohungarites tuberculatus (Welter)
Procarnites skanderbegis Arthaber
Albanites welteri Spath

The *Prohungarites* of this fauna are very similar to the species recorded from southeastern Idaho and suggest a close relationship between these two faunas. The *Albanites, Proptychitoides, Eophyllites,* and *Prenkites* are comparable to species known from Albania (Arthaber, 1911) and the Greek island of Chios (Renz and Renz, 1948). It is the Idaho fauna, however, that gives us the real clue to the stratigraphic position of the fauna from Block "E".

The youngest Scythian zone in the Himalayas is that from the Chocolate limestone at Byans which belongs to the *Anasibirites* zone (Krafft and Diener, 1909). Diener established the existence of two Scythian zones in Kashmir, a lower one belonging to the *Ophiceras* zone and an upper one equivalent to the Hedenstroemia fauna at Spiti. In addition, Diener recognized the possibility of a third zone in the presence of *Prohungarites middlemissi* (Diener). This specimen, however, Diener clearly states came from loose blocks at Pastannah, Kashmir, so that its stratigraphic position is not known. Spath (1934, p. 33) placed this form in his Prohungaritan division at the top of the Scythian.

In the Salt Range, the youngest zone represented by the Ceratite beds (in the Upper Ceratite limestone) is of the *Anasibirites* zone. Above this uppermost fossiliferous horizon, Waagen (1895) recorded a single species, *Pseudharpoceras spiniger,* from the Topmost limestone. Waagen had a single, incomplete specimen from this horizon upon which he established his new genus and species. This form has been largely overlooked since its introduction but Smith (1932) did recognize what he believed to be a conspecific form in the *Columbites* zone of southeastern Idaho. Waagen's specimen is incomplete and weathered but does bear a close similarity to *Hellenites* Renz and Renz (1948) from the Upper Scythian fauna of Chios.

The lower Triassic appears to be well represented in the Karatou Mountains in the Mangyshlak Peninsula (projecting into the eastern Caspian Sea) of southern Russia. This area is especially well known for the presence of *Doricranites* — the type species, *D. bogdoanus* — which was described by v. Buch in 1831. Mojsisovics (1882) subsequently described two additional species. The very unusual nature of *Doricranites* presented a problem as to its correct age assignment but most authors (Mojsisovics, 1882, p. 89; Spath, 1934, p. 382) concluded it was most likely upper Scythian in age. In the meantime, additional forms have been identified from the region with some data on the stratigraphy. Baiarunas (1936) was the first to present a stratigraphic sequence with a list of the ammonites present, which unfortunately include many *nomina nuda*. According to Baiarunas the lowest 15 m. of the Triassic section consist of limestones and marls which contain *Doricranites bogdoanus* v. Buch, *D. rossicus* Mojsisovics, *D. acutus* Mojsisovics, and *Subdoricranites discoides* (*nomina nuda* for both genus and species). It is of interest to note Baiarunas' comment that this fauna was characterized by numerous individuals but few species. Above this lower fossiliferous unit are 100 m. of unfossiliferous siliceous shales. This is followed by 200 m. of marly shales with seams of marly limestone and calcareous marly concretions, rich in ammonites. This series of strata is divisible into four divisions; the lowest part of 23 m. contains *Ophiceras* cf. *demissum*, *Xenodiscus* sp., *Pseudosageceras multilobatum* Noetling, *Neotoceras mokrinskii* Baiarunas (both genus and species *nomina nuda*). The next 30 m. are chiefly characterized by *Pseudosageceras multilobatum* Noetling, *Procolumbites karataueiki* Baiarunas (both genus and species *nomina nuda*), *Procarnites andrusovi* Baiarunas (*nomina nuda*), *Thermalites* n. sp. and other species. The third division of 80 m. contains *Columbites* cf. *parisianus* Hyatt and Smith, *C. asiaticus* Baiarunas (*nomina nuda*), *C. adai* Baiarunas (*nomina nuda*), *C. dolnapensis* Baiarunas (*nomina nuda*), *C. ligatiformis* Baiarunas (*nomina nuda*), *C. tururpensis* Baiarunas (*nomina nuda*), *C. gracilis* Baiarunas (*nomina nuda*), *Tirolites* n. sp. and others (unnamed). The uppermost division of 65 m. is characterized by several forms of *Tirolites* and *Dinarites*.

On the basis of this faunal sequence, Baiarunas (1936) came to the conclusion that since *Doricranites* lay below the beds containing *Pseudosageceras* and *Ophiceras,* the *Doricranites* strata must be correlative with the *Otoceras* beds of the Himalayas, that is, at the base of the Scythian. Each of these faunal assemblages represents a strange mixture of genera normally not found together. This fact plus the large number of *nomina nuda* in the faunal list throws suspicion on the whole study and especially on the conclusions.

Kiparisova (1947) briefly discussed the Mangyshlak section and described some of the ammonites, making specific note of the fact that detailed stratigraphic data were lacking for much of the material available to her. However, she did describe from the upper unit (the 80 m. unit below the uppermost division of 65 m. with *Tirolites* and *Dinarites*) of Baiarunas's section *Columbites dolnapaensis* Kiparisova (= *C. dolnapaensis* Baiarunas MS), *Kashmirites subdimorphus* Kiparisova, *Anasibirites gracilis* Kiparisova (= *Columbites gracilis* Baiarunas MS), and *Tirolites rossicus* Kiparisova.

Recently the stratigraphy of the Mangyshlak region was again briefly reviewed in the volume on the stratigraphy of the USSR by L. P. Kiparisova (1958). Following this author, the Mangyshlak section begins with up to 250 m. of calcareous shales of which the lower 10 m. consists of sandy shale and coarse sandstone with lenses of conglomerate. Above the lower sandy bed the shales contain beds of limestone with abundant ammonoids (*Doricranites bogdoanus* v. Buch, *Tirolites cassianus* Quenstedt, *Procarnites andrusovi* Kiparisova, *Pseudosageceras multilobatum* Noetling, etc.) and pelecypods. Above this are up to 400 m. of argillaceous and sandy shales with interbedded limestone and sandstone. The limestones contain ammonoids (*Columbites* cf. *parisianus* Hyatt and Smith, *Tirolites cassianus* Quenstedt, *Procarnites andrusovi* Kiparisova, *Anasibirites gracilis* Kiparisova, and others) and pelecypods, gastropods and brachiopods. Kiparisova placed these horizons in the upper half of the Scythian.

The incompleteness of these faunal lists, the mixture of genera and species which have not previously been recorded together, and the great thickness of each of the fossiliferous units with no data on the precise stratigraphic relations of the faunas makes interpretation of this section extremely difficult. For one thing, one cannot help but be impressed by the presence of *Procarnites andrusovi* and *Tirolites cassianus* in both of the fossiliferous units. *Procarnites* has previously been recorded from the *Subcolumbites* beds of Albania (Arthaber, 1911) and of Chios (Renz and Renz, 1948). Spath (1934, p. 182) identified specimens in the collections of the British Museum (Natural History) as *Procarnites skanderbegis* Arthaber, from the Nifoekoko locality in Timor (*Albanites* beds). Species of *Tirolites* are best known from the Alpine fauna described by Kittl (1903) and have long been known from southeastern Idaho where they occur in a horizon above the *Anasibirites* zone and below the zone of *Columbites.* Species of *Tirolites* are also known from the *Columbites* zone of southeastern Idaho and from the *Hedenstroemia* beds of the Himalayas (*Tirolites injucundus* Krafft in Krafft and Diener, 1909). No species of *Tirolites* have been recognized in any of the faunas of the *Prohungarites* zone. *Pseudosageceras multilobatum* is world wide in distribution and ranges throughout the Scythian. The specimen identified by Kiparisova as *Anasibirites gracilis* has the appearance of a *Xenoceltites.*

It is apparent from the faunal lists of the Mangyshlak section that several Upper Scythian zones are represented, but until detailed field studies and sections are made and the faunas monographed one cannot evaluate the relationships of these faunas with others of similar age. There is nothing in the specimens known to date from Mangyshlak that shows any affinity to the *Arctoceras* fauna of Spitsbergen.

The Lower Triassic faunas of Djulfa in Armenia are still poorly understood. The best description of the faunas is that of Stoyanow (1910), and the stratigraphy and geology of the region has been well treated by Bonnet (1947). There is a general consensus of opinion that some upper Scythian horizons are represented, but for the immediate purposes of this report it is sufficient to say that the faunas are totally unlike the *Arctoceras* fauna of Spitsbergen.

The upper Scythian faunas of the Mediterranean region need only brief mention. These include the *Tirolites* fauna monographed by Kittl (1903) and the *Subcolumbites* fauna first described by Arthaber (1908, 1911) from Albania and more recently described from the island of Chios by Renz and Renz (1948). The *Subcolumbites* fauna of Albania and Chios is extremely diverse in numbers of genera, many of which show close affinities to the fauna from Block "E" bei Nifoekoko, Timor, and to the *Prohungarites* fauna of southeastern Idaho. The only form in common with the *Arctoceras* fauna of Spitsbergen is the genus *Prosphingites.* However, as mentioned earlier, the species of *Prosphingites* from the *Subcolumbites* fauna of Albania and Chios are very different from the Spitsbergen species or from those species in the *Meekoceras* fauna of western United States.

If one takes into account the composition of all the faunas known from the *Prohungarites* zone (Olenek, Ussuri Bay, Queen Elizabeth Islands, southeastern Idaho, Nevada, Timor, Kashmir, Mangyshlak ?, Djulfa, Chios, and Albania), there are very few forms which could indicate any possible relationship to the *Arctoceras* fauna of Spitsbergen. The *Columbites* and *Tirolites* faunas are known from very few localities and are known in a sequence of faunal zones only in southeastern Idaho. What we know of these faunas likewise does not suggest any close relationship to the *Arctoceras* fauna of Spitsbergen. The relationship of the *Arctoceras* fauna with the zone of *Meekoceras gracilitatus* is based on the close similarity of *Arctoceras blomstrandi* to "*Meekoceras*" *tuberculatum* and to the similarity of *Prosphingites spathi* to the new prosphingitids known from the *Meekoceras* beds of Nevada. However, if it is correct that the *Arctoceras* fauna of Spitsbergen occurs above the *Anasibirites* fauna, then it could not be contemporaneous with the *Meekoceras* fauna of Idaho and it must then represent an additional zone (best considered of Owenitan age) lying above the *Anasibirites* zone and below that of *Tirolites*.

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